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Miscellaneous Products

INTRODUCTION

Byproducts of milk and individual milk components have been used in the manufacture of a wide variety of prepared and packaged foods. Although they are usually the most highly nutritious component in a food, they are often the most costly and hence the economic incentive to cut costs by substituting cheaper vegetable materials for milk fractions. In products such as egg or meat substitutes, milk constituents themselves replace more expensive ingredients. But here milk byproducts are important because they improve the body, flavor, and nutritional characteristics of the products to which they are added. Sometimes milk byproducts are used as components of certain dietary foods prepared for persons in particular age groups.

A mixture of approximately equal weights of dried skim milk and sugar which can be dispersed quickly in water has been advocated for mass feeding of people in cases of disaster. A combined sugar and skim milk food appears to be useful in the gastrointestinal disturbances that accompany radiation sickness.

Byproducts in concentrated form are needed in the preparation of most foods. The food manufacturer can choose from many kinds of bulk packed concentrates that are available in wholesale channels. The homemaker, however, whose potential requirement for milk products in home prepared foods is very great, is limited in her selection to those forms she can purchase in retail stores. These include the sweetened condensed and evaporated milks, and various types of dried milks. Recipes for domestic use of these milks are available from the appropriate trade associations. The school lunch program is utilizing large quantities of nonfat dried milk in the preparation of school luncheon dishes.

The use of byproducts from milk in a variety of foods not included in other chapters will be discussed here. These uses provide a substantial by-product outlet. Only a sustained program of research and development on dairy foods will produce the new products needed to maintain both a

healthy population and a healthy dairy economy. It should be emphasized that milk byproducts can make a substantial contribution to the nutritional value of our food supply, thus compensating for the nutritional poverty of some of our common foods and beverages. The nutritional characteristics of milk components are discussed in Chap. 13. Alesch (1958), Habighurst and Singleton (1965), and Weisberg and Goldsmith (1968) have discussed the use of whey in a wide variety of foods. Mykelby (1968) has developed formulations for use of sodium caseinate in many foods.

FRESH BEVERAGES FROM BYPRODUCTS

Many flavored beverages have been made from milk, skim milk, buttermilk, whey and some of their components. Indeed all of these dairy products have been widely used as a beverage without added flavor. All but whey have an acceptable natural flavor but flavoring ingredients are used as a means of increasing or widening markets. Even "whay drinking" without benefit of flavoring was advocated by Samuel Pepys as early as 1663. Fermented beverages from skim milk are discussed in Chap. 2, from whey in Chap. 3. Sterilized beverages are covered in Chap. 8. This discussion will be concerned only with the fresh products.

Chocolate-flavored Milk

Chocolate-flavored milk is made by dairies in most sections of the United States, usually as a pasteurized, homogenized, chocolate-flavored milk, skim milk, or partially skimmed milk which is merchandised in paper, glass, or plastic containers. Chocolate milk is the most popular flavored milk (Holland 1968; Langlois and Randolph 1967).

Ingredients.—Skim milk, partially skimmed milk, or whole milk may be used as the basis of chocolate-flavored milk. Factors other than fat content being the same, the palatability of the beverage varies directly with the percentage of fat. Milk with 2 to 3.5% fat is most commonly used.

Many states and cities have regulations governing the manufacture, sale, and labeling of chocolate milk. Some states permit the names "Chocolate Milk" and "Chocolate-flavored Milk" to be used only on products made from whole milk, and, if skimmed milk is used, permit only such designations as "Chocolate Drink" or "Dairy Drink." Local authorities should be consulted before attempts are made to sell these products.

Cocoa is the most widely used flavoring material, but liquor chocolate, which is usually considered to have a better flavor, can be used although there are troublesome stability difficulties which must be overcome. Stabilized chocolate syrups can be obtained which may be added directly to the milk. Cocos differ widely in their physical characteristics, the most pronounced differences being between the so-called Dutch-process and

American-process cocoas. It is not necessary, however, to know the details of cocoa manufacture in order to select a suitable cocoa, since it will be judged on the basis of the flavor of the chocolate milk produced. Cocoa is used in the proportion of 1.0 to 1.5%, liquor chocolate in the proportion of 1.5 to 2.0%.

The percentage of sugar in chocolate milk is usually between 5 and 8. In proportioning sugar and chocolate, it should be borne in mind that a high degree of sweetness and strong flavor have a greater initial taste appeal than a low degree of sweetness and less flavor, but satisfy the appetite sooner and tend to become cloying.

Vanilla, 0.1 to 0.2% of salt, and spices in very small proportions may be added to enhance the flavor.

A stabilizer is usually added to delay or prevent settling of cocoa particles. It also aids in the prevention of cream rising. One percent of starch, gelatinized by heating in the milk to 190° F, 0.3% of gelatin, additional msnf added as condensed skim milk, 0.2% of sodium alginate, and carrageenan in a concentration of 0.04%, are the stabilizing agents that have been most commonly used. The presence of these substances increases the viscosity of the chocolate milk which, if excessive is undesirable since a highly viscous product may entrap air bubbles or may have the appearance of having curdled and extruded whey. Although the prevention of settling of cocoa particles is considered to be due largely to the increase in viscosity produced by stabilizers, other factors are involved; for it has been shown that sodium alginate and carrageenan effectively prevent sedimentation at a viscosity level lower than that necessary when other stabilizers are used.

Processing.—The milk used in making chocolate-flavored milk is homogenized to prevent or delay the rising of cream. It may be homogenized after the addition of cocoa and sugar, but this has the effect of increasing sedimentation. After all the ingredients have been added, pasteurization is carried out for the usual sanitary reasons and to aid in the prevention of rising of cream.

Syrups containing cocoa, sugar and stabilizer or dry mixtures of cocoa and stabilizer may be purchased. Syrups are added to heated homogenized milk, and the mixture pasteurized, bottled, and cooled. The dry mixes may be mixed with sugar before being added to the milk.

Syrups may be made in the dairy plant, if desired, in quantity sufficient for several days use, or the chocolate milk may be prepared each time by adding cocoa, sugar, and stabilizer directly to the milk without the preliminary preparation of a syrup. Directions are given for both these procedures.

Procedures.—For a syrup to be used in making a chocolate milk containing 1% cocoa, 5% sugar, and 0.2% sodium alginate, these 3 ingredients are

weighed out in the proportion given. The 0.2 part of alginate is mixed thoroughly with 5 times its weight of sugar, and the 1 part of cocoa similarly mixed with the remainder—4 parts—of the sugar. To the mixture of cocoa and sugar, 4 parts of sweet skim milk are slowly added with stirring and the syrup is stirred until smooth. It is then heated to 150° F and the mixture of alginate and sugar added gradually with stirring. The syrup is then heated to between 180° and 190° F, held for 15 min, then quickly cooled to below 50° F, and held at this temperature until used. If water is used instead of skim milk, the syrup will have better keeping quality, but there will be greater dilution of the nonfat solids in the finished chocolate milk. Greater proportions of cocoa and sugar may be used in the syrup if more flavor and sweetness are wanted in the product. If liquor chocolate is used instead of cocoa, it is melted, thinned gradually with skim milk to a smooth paste, the alginate and sugar added to the hot paste, and the mixture heated and cooled as directed above.

To make the chocolate milk, 90 parts of sweet skim milk, partially skimmed milk, or whole milk are heated to 140° to 145° F and homogenized at 1500 to 2000 lb pressure. Ten parts of the syrup, prepared as described, are thoroughly mixed with the milk and the mixture is pasteurized. It is cooled rapidly, bottled, and held at a temperature below 50° F, until used.

To prepare a chocolate milk of the composition given above without the preliminary preparation of a syrup, 1 part of cocoa previously mixed with an equal weight of sugar is added to 90 parts of homogenized milk and the mixture heated with stirring to 150° F. The 0.2 part of sodium alginate mixed with 5 times its weight of sugar is then added gradually and thoroughly stirred in. The remaining 3 parts of sugar (making altogether 5 parts of sugar) are then added, the mixture heated at 145° to 150° F for 30 min, cooled rapidly, bottled, and refrigerated below 50° F until used.

Carrageenan in the proportion of 0.04 part may be substituted for the 0.2 part of alginate. It is claimed that 0.04% of carrageenan is adequate to prevent settling of cocoa fiber and rise of fat and that this stabilizing effect is obtained without producing an objectionable thickening of the milk. Larger percentages of carrageenan may cause thickening. Nongelling carrageenan with high suspending strength has been developed for use in chocolate milk. A process for stabilizing chocolate milk by means of a mixture of carrageenan and alginate has been patented (Fouts and Mull 1943).

The use of a mixture of starch with agar or with other gums has been patented (Linn 1935). The chocolate milk contains between 1 and 3% starch and between 0.01 and 0.20% gum and is heated for from 20 to 30

min at 170° to 200° F to gelatinize the starch. Higher temperatures should be avoided, since they cause thickening of the milk by coagulating casein.

Fruit-flavored Dairy Beverages

Strawberry-flavored milk is much less popular than chocolate but it is the only fruit flavored milk to attain even a small volume. Fruit-flavored milks should offer excellent opportunities to increase fluid milk sales but the many attempts to create and market new flavored products have not had lasting success. Skim milk or partially skimmed milk can be used in place of whole milk but flavor is inferior and its casein stability problems are the same as with whole milk. One part by volume of a flavoring syrup to eight parts of milk is a good proportion for an experimental start. Whey, lacking acid coagulable casein, offers a milk ingredient suitable for mixing and processing with fruit juices. Purées or juices made from berries, apple, apricot, cherry, peach, pineapple or citrus fruits can be attractive but must be promoted to provide sizable markets. Tomato juice blends with whey make a tasty beverage and the heated mixture is a base for a smooth cream style soup.

Clear beverages, sometimes carbonated, have been prepared by clarification of whey and addition of fruit juices or flavoring. A suitable process would involve removal of coagulable protein, decolorization, and filtration. The residual liquid containing lactose, salts, and soluble nitrogen contributes little more than water toward flavor. Its use on this basis has been difficult to justify economically.

Holland (1968) has suggested formulas for strawberry and orange milk. The strawberry milk is made by blending 5 qt of strawberry purée base and 10 ml 15% phosphoric acid with 36 qt of pasteurized homogenized whole milk. One problem with blending fruits into milk is that they taste best at acid levels below pH 5.7 but this acidity tends to coagulate the casein. At pH 5.8 or above the products are usually sweet and insipid.

Dairy drinks containing casein can be stabilized by pectin which can be used in the form of apple or quince pulp or by use of carboxymethyl cellulose (CMC). Monzini (1964) found that fruit juice or purée could be mixed with milk or skim milk in proportions of about 1.5 parts of fruit to 1 part of milk. Stabilization depended upon the type of fruit and its natural pectin content. Pectin or CMC was also used to supplement natural pectin as needed up to about 0.25% of the mixture.

Hedrick *et al.* (1968) used low viscosity CMC at the 0.25% concentration to stabilize a cherry milk mixture but it did not prevent coagulation of the pasteurized milk drink. More CMC resulted in some serum separation. Dibasic potassium phosphate provided casein stabilization during

pasteurization at 145° F for 30 min (Schanderl and Hedrick 1968). A satisfactory formula was:

	% By Weight
Whole milk (3.5% fat)	82.95
Sugar	9.60
Cherry concentrate (62% solids, pH 3.42)	7.20
Dipotassium phosphate	0.25
Food grade red coloring	

BYPRODUCTS FOR FROZEN DESSERTS

Skim milk, buttermilk and whey are sources of milk solids in the manufacture of ice cream, ice milk, sherbet, and milk shake mix. Unusual types of mixes that may be considered as byproducts, or that utilize byproducts are discussed elsewhere: condensed mix in Chap. 4, dried mix in Chap. 5, and canned mix in Chap. 8.

Skim Milk

Skim milk in various forms is a normal constituent of ice cream mix, and processes for its manufacture have been presented in Chap. 4 and 5. A tabulation of normal conditions for the preparation and use of skim milk in ice cream and other special foods is presented in Table 10.1. Some forms of skim milk such as dispersible casein products (Chap. 11) and enzyme hydrolyzed low lactose milk (Chap. 4) are not included in Table 10.1. A heavy bodied viscous skim milk is desired for some food uses. The products shown in Table 10.1 vary in viscosity depending on heat treatment. Milk shake bases are similar to ice cream mixes but vary in composition depending upon the requirements of the user. A stabilizer such as carrageenan may be used to give the desired viscosity. By combining the two gums, CMC and MC, it is possible to obtain a constant uniform viscosity over a wide temperature range (Farkas and Glicksman 1967). Sodium caseinate may be used in lieu of some of the skim milk solids to increase the protein content of ice cream mixes and milk shakes. Sodium caseinate used at the level of 4–6% of total solids, improves the whipping properties of the mix to which it is added and contributes to smoothness of body and texture.

Buttermilk

Buttermilk has been utilized with considerable success as an ice cream ingredient. Its use is limited to the small quantities of the required high grade of sweet cream buttermilk that are produced. Neutralized sour

MANUFACTURE AND STORAGE OF SKIM MILK PRODUCTS FOR USE IN ICE CREAM OR OTHER FOODS

TABLE 10.1

Process of Manufacture				Characteristics of Finished Product			Satisfactory Storage		Relative Merits for Ice cream Use		
Kind of Skim milk Concentrate	Forewarming Treatment, °F	Sugar Added per 100 lb Skim Milk, Lb	Total Solids Content After Concentration, %	Treatment of Concentrate	Composition			Viscosity, Centipoises	Wt. %	Advantages	Disadvantages
					Solids-not-fat, %	Sugar, %	Water, %				
Condensed Plain	160	20	30	Cool to 40°F	30	0	70	70	40	2 Fresh product easy to prepare	Perishable
Superheated	160	20	30	Heat to 190°F until thickened; cool by vacuum	30	0	70	40,000	40	2 Makes viscous smooth mix	Difficult to handle; viscous; perishable
Frozen	145	30	30	Cool to 34°F; freeze at -10°F	30	0	70	100	0	12 Suitable for storage	Protein gradually becomes insoluble during storage
Low-lactose	145	10	5.9	Hold quiescent at 68°F for 20 hr; centrifuge to remove crystallized lactose	33	30	37	20,000	40	4 62% of lactose removed; can be used to raise msnf of mix	Viscous; semi-perishable
Sweetened	180	15	12.8	Continuously cool to 60°F or cool in vat with stirring to 86°F to crystallize lactose	30	42	28	8,000	60	52 Suitable for storage and retention of milk flavor	Viscosity increases in storage; may become difficult to handle
Dried	160	20	0	Heat to 160°F or higher, and spray dry	97	0	3	—	70	52 Especially suitable for long-term storage	Requires reconstitution; develops stale flavor in storage

cream buttermilk is of poor quality, carries objectionable flavors, and is not suitable as a constituent of ice cream. Satisfactory buttermilk can be obtained from cream with a titratable acidity of less than 0.25%.

Buttermilk is difficult to preserve without deterioration. Fresh and plain condensed buttermilk are perishable. Dried sweet cream buttermilk quickly becomes oxidized and has a shorter storage life than dried whole milk. Sweetened condensed buttermilk may be a satisfactory form in which to store sweet cream buttermilk for use in ice cream or confections (Spoehr 1938).

Buttermilk improves the whipping properties of ice cream mixes, probably because of its high lecithin content. Lecithin is associated with the milk fat and is concentrated in the buttermilk during churning. Buttermilk (Thomas and Combs 1944) whether fresh, condensed, or dried will usually improve whipping when it replaces most of the skim milk solids used in the mix.

TABLE 10.2
COMPOSITION OF WHEY SHERBETS MADE FROM FOUR SOURCES
OF WHEY SOLIDS^{1,2}

Source of Whey in Sherbet	Ingredient	Weight Lb	Directions for Mixing
Fluid whey, 6.4% ts	Cane sugar	21.0	Blend the sugars and stabilizer, and add to the fresh fluid whey. Pasteurize, and cool.
	Corn sugar	7.0	
	Fresh fluid whey	71.5	
	Stabilizer (pectin or gelatin)	.5	
Plain condensed whey, 60% ts	Water	63.17	Combine the water and whey. Blend the sugars and stabilizer and add to the water-whey mixture before it reaches pasteurizing temperature. Pasteurize, and cool.
	Cane sugar	21.00	
	Corn sugar	7.00	
	Plain condensed whey	8.33	
	Stabilizer (pectin or gelatin)	.50	
Sweetened condensed whey, 38% cane sugar, 38% whey solids	Water	63.35	Combine the water and whey. Blend the sugars and stabilizer and add to the water-whey mixture before it reaches pasteurizing temperature. Pasteurize, and cool.
	Cane sugar	16.00	
	Corn sugar	7.00	
	Sweetened condensed whey	13.15	
	Stabilizer (pectin or gelatin)	.50	
Dried whey, 95% ts	Water (room temperature)	66.25	Blend the sugars, dried whey, and stabilizer. Add this mixture to the water slowly, while agitating or stirring the mixture. Pasteurize, and cool.
	Cane sugar	21.00	
	Corn sugar	7.00	
	Dried whey	5.25	
	Stabilizer (pectin or gelatin)	.50	

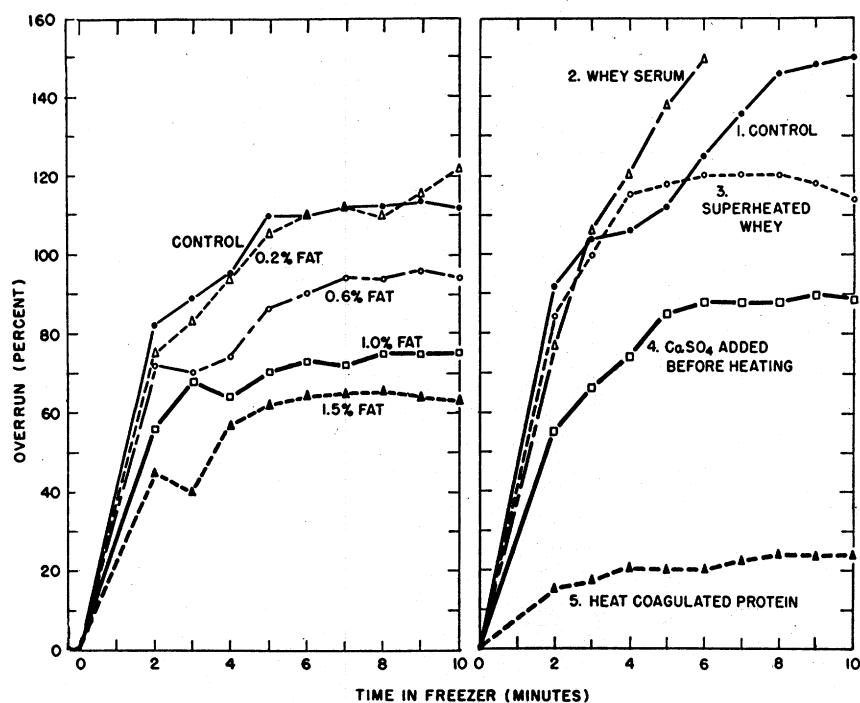
¹Potter and Williams (1949).

²To avoid excessive overrun, each sherbet should contain 1% fat added as cream; 2.5 lb of 40% or 5 lb of 20% cream may be used in each formula.

Flavor, body, and texture improvements can be made in an ice cream by the use of high quality sweet cream buttermilk. Buttermilk imparts a rich creamy flavor and its strong emulsifying properties develop a smooth body and texture and help to retard the growth of large ice crystals during hardening of ice cream.

Whey

Whey, in fresh form, as plain, sweetened condensed, or dried whey is an excellent source of milk-derived solids in sherbet. It improves the body and texture of sherbet by producing greater smoothness than is possessed by normal sherbet made with ice cream mix. The composition of whey



Potter and Williams (1949)

FIG. 10.1. THE EFFECT IN A BATCH TYPE FREEZER OF DIFFERENT PERCENTAGES OF FAT UPON THE WHIPPING PROPERTIES OF WHEY SHERBETS

Effects of various treatments of whey and whey constituents upon the whipping properties of sherbets containing these products: (1) fresh Cheddar cheese whey; (2) whey from which the protein had been removed after heating at 190°F for 10 min; (3) whey condensed to 40% total solids and heated in a vacuum pan to 200°F; (4) whey containing 330 gm calcium sulfate per 100 lb, heated to 208°F for 10 min, and condensed to 30% total solids; and (5) protein removed after heating whey to 190°F for 10 min, dispersed in a sugar base, and homogenized.

sherbets made from various sources of whey is shown in Table 10.2 (Potter and Williams 1949). The sherbets contain 4 to 5% whey solids. When cottage cheese whey is used, the customary addition of citric acid to fruit-flavored sherbets may be greatly reduced or eliminated.

Potter and Williams (1949) found that whey greatly improved the whipping properties of sherbets. Excessive incorporation of air during freezing was avoided by the addition of 0.6 to 2% fat to the sherbet mix which was then homogenized. The depressing effect of fat upon the development of overrun in whey sherbet is shown in Fig. 10.1. An analysis of the effect of the constituents of whey upon the whipping properties of sherbets showed that the presence of heat-coagulated whey protein decreased whipping and that the nonheat-coagulable nitrogen fraction of the serum was the active foam-producing agent. The use of whey in sherbet made it possible to attain adequate overrun under composition or freezing conditions which produced a depressing effect upon the whipping of nonwhey mixes.

CONFECTIONS

The byproducts of milk used in confections are skim milk, buttermilk, and whey or products derived from them. Bettes (1966) has reviewed the preparation and use of dairy products for candy manufacture.

Candy of highest quality contains milk fat from whole milk products, cream, or butter. The candy industry, perhaps more than any other segment of the food industry, has demonstrated by actual usage the great value of milk fat as a flavoring ingredient. The confectionery industry uses about 7% of the various condensed whole and skim milks produced in the United States. Production and composition figures are shown in Chap. 1, Table 1.1. Whole milk is believed to comprise about 44% of the total milk utilized in confections. This is in sharp contrast to the baking industry where milk usage is largely skim milk in the dry form. Of total U.S. domestic nongovernment use of nonfat dried milk, 26% is for bakery, and 2% for confectionery purposes.

Candy making is, to some extent, an art taught by apprenticeship and experience with less fundamental scientific background than has been accumulated by some other industries. Nevertheless, the industry has made remarkable progress in the production of stable, uniform, and attractive goods. The milk products used by confectioners are those that are commercially available to the food industry. The dairy and the candy industries have made little effort to determine what kind of treatment should go into the manufacture of milk products that are to be used in candy. The heat and other treatments incidental to preparation of the concentrated and dried milks can greatly affect the physical characteristics of finished

dairy products and their behavior in some of the candy making processes. It seems reasonable to assume that if the two industries determined the basic physical and chemical requirements of good dairy ingredients and if such ingredients were produced especially for candymakers, greater utilization of milk products in candy would result. Unconventional products made for candy use in the past have often been from secret formulas and have involved unusual and optimum ratios of milk fat-nonfat milk solids-sugar designed for special production of large confectioners.

Milk products usually appear in candy formulas in the condensed or dried form. It is more efficient for the confectioner to pay the milk processor to concentrate milk in large scale equipment than it is to have his candymaker boil off the water in small batches. Furthermore, excessive boiling of thin, dilute mixtures that contain milk protein may cause the protein to coagulate in large aggregates, thus producing a coarse texture in the candy. The manufacture of the standard milk concentrates is described in other chapters. Confectioners sometimes order special concentrates to meet the requirements of individual formulas. These usually have not deviated greatly from conventional milk products. One such "plastic" or high-solids sweetened condensed milk contains approximately 13% milk fat, 35–37% msnf, 30% sugar, and 20–22% water.

Functions of Milk Constituents in Candy

Each milk constituent, except the minerals, can be shown to perform useful functions in candy other than the recognized addition to nutritive value. The lactose, protein, and fat are also responsible for certain types of deterioration. There is no evidence to show that the minerals of milk play a significant role in the physicochemical problems of the candymaker. They may, however, affect the behavior of the protein during the cooking process, and they also contribute a certain characteristic saltiness which helps produce a well-rounded milk flavor.

Lactose.—Lactose is the least sweet of the sugars that are used in confections. In a generally accepted scale of sweetness in which sucrose is 100, lactose is 16, glucose 70, levulose 173, and corn syrup 30 (Biester *et al.* 1925). Lactose can thus aid in decreasing the sweetness of oversweet candy.

Lactose is less soluble than the other common sugars. In the supersaturated state it will crystallize readily if moisture is available to satisfy the requirement of a molecule of water of crystallization per molecule of lactose and if nuclei are present on which crystals can grow. If the syrup phase of fondant is supersaturated with respect to lactose this will often cause a sandy texture to develop during storage. However, an attractive, mildly sweet cream fondant can be produced by crystallizing pure lac-

tose in an invert sugar syrup. Whittier (1953) developed a process for making confections in which lactose was converted in the product from an anhydrous, amorphous, to a hydrated crystalline form. Finely ground confectioners sugar and dry flavoring materials were mixed with a dried milk product containing amorphous lactose, water or milk slowly added to make a workable paste and the lactose allowed to crystallize to form a firm icing or fondant.

The physical state of lactose in candy may have an important effect on the apparent freshness of some confections. As long as the lactose remains amorphous there will be softness, elasticity, and freshness of body. If crystallization proceeds slowly during storage, the structure may become crumbly, dry, and hard. A gradual crystallization of lactose in candy can be avoided by so choosing the ingredients that there is an ample supply of inhibiting materials such as invert and corn syrup, protein, and fat. Some of these substances should be present even in whey fudge. A fine granular structure can be obtained in whey fudge by quickly crystallizing the lactose so as to produce small crystals.

The use of excessive quantities of lactose in caramels may induce crystallization, and before the lactose begins to crystallize, the caramel can be very sticky. The sticky characteristic will disappear with age as crystallization sets in. Stickiness will be avoided if the lactose is added to the candy as a component of milk or skim milk rather than whey. The relatively large portion of protein associated with the lactose in the milk products helps to inhibit lactose crystallization. Whey, being low in protein and high in lactose, will produce a sticky caramel that will grain easily unless the whey solids content of the caramel is held below 15% or unless additional milk solids are used in the formula.

Lactose is known to adsorb riboflavin and other pigments on its crystal faces during crystallization. This adsorptive power may enable the crystallized lactose of fudge type candies to hold vanilla and various flavors and pigments longer than when the candy contains no lactose.

Refined lactose is expensive for fondant or special usage while technical grades that contain appreciable quantities of protein often cause excessive foam during cooking. This foaming can be eliminated by digesting the whey protein with trypsin prior to separation of the lactose (Webb and Ramsdell 1944).

The presence of milk protein and lactose together in a white fondant eventually causes discoloration in storage. However, the association of protein and lactose during cooking helps to produce the attractive brown color of many candies.

Milk Protein.—The confectioner depends upon protein to produce foam in the manufacture of marshmallow, nougat creams, and special

whips. Gelatin and egg albumin are the favorite proteins for this purpose although whey protein can be used. Most whey protein preparations are rather salty in flavor and inferior in foam production to gelatin and egg white. However, attractive whey candies that depend upon whey protein for air incorporation will be described later in this chapter.

Milk protein is essential to the development of proper body, flavor, and color in such cooked candies as caramel and fudge. The favorable characteristics produced by the milk protein are largely developed in the candy mass during the cooking process.

Casein and whey protein function differently in candy. Casein is capable of forming a firm, resilient, chewy type of body which is neither sticky nor tough. As the candy mass boils in the cooking process, it is essential that the casein coagulates in a finely dispersed state to insure smoothness. Coagulation appears inevitable because the casein is destabilized both by high cooking temperatures and by high concentrations of proteins, sugars, salts, and other ingredients.

The fineness of the casein coagulum is governed by the conditions present at the time of coagulation, such as the speed of agitation just preceding and during coagulation, the viscosity of the hot mass, and the concentration of casein in the mixture. Severe agitation during coagulation of concentrated milks produces a finely dispersed coagulum but one of lower viscosity than when the heating is done with little or no agitation. The viscosity of the boiling candy mixture is usually great enough to insure the formation of a fine protein coagulum provided its formation is accompanied by vigorous stirring. The viscosity of the mixture may be increased by increasing its protein content or by adding such body building ingredients as dextrin, starch, or other cereal products.

Buttermilk protein is less effective in building firmness of body in cooked candy than skim milk protein but it does produce some firming effect. Buttermilk, because of its high lecithin content, is more useful than skim milk in helping to form smooth emulsions and in producing a creamy body.

Whey protein forms a soft flocculent coagulum which is less capable of contributing firmness to the structure of candy than casein. Indeed, 40% of the nitrogen in whey is present in soluble, nonheat-coagulable form and this material does not aid in the development of a firm structure.

The whey proteins surpass casein in foaming characteristics. At high concentrations and viscosities, such as may be found in sweetened condensed whey, a moderately stiff foam of good stability can be formed. A whipped whey or milk albumin foam cannot be set by heat, a property unique with egg white. A coagulable whey-protein foaming agent can be produced from a condensed whey paste (Beeching and Severn 1944). Part

of the lactose is removed from the condensed whey, the whey is diluted with water, made alkaline, treated with a flocculating agent, acidified, and filtered. The clear liquor contains the active foam-producing constituents of the whey and imparts foaming properties to aqueous solutions. Modern techniques of reverse osmosis, electrodialysis, and gel filtration offer possibilities for preparing improved salt-free whey proteins (Chap. 11).

Whey foam can be used to introduce air in a candy mixture but means must be provided to stabilize the structure and prevent escape of the air. This can be accomplished by first whipping the whey product and then carefully folding it into the cooked and partially cooled candy or syrup base. The foam will be quite stable if the base contains no fat. The hardening mixture entraps and permanently holds the air. This type of treatment is well illustrated by the process for making "whipped fudge" described in the candy formula section. Since fat quickly destabilizes a whey foam, any fatty ingredients such as chocolate should be carefully folded into the mixture at the latest possible moment before it becomes too cool and viscous for proper mixing.

A porous confection can be made from whipped sweetened condensed whey by drying the foam before it can collapse. The whipped mixture may be stabilized by the addition of a precooked cereal. However, the product will become sticky and finally the lactose will crystallize if it is allowed to take up moisture. Chocolate coating is effective in retarding moisture absorption (See "Wheyfers" in Table 10.4).

The color of highly cooked candies that contain milk is caused by the familiar browning reaction between protein and the sugars of the mixture. The pleasing caramel flavor develops simultaneously with the color. The intensity of this milk-caramel flavor is partly dependent upon the quantity of milk protein used in the candy.

Milk Fat.—Milk fat cannot be omitted from a discussion of candy ingredients although it is often absent or present only in limited amounts in byproducts. Milk fat is a relatively soft fat which melts between 82° and 97° F. A blend of milk fat and of a higher melting fat is often used by confectioners to give firmness to candy. Milk fat itself performs the usual functions of any fat of the same melting point, that of building up a pliable, plastic body.

The most important function of milk fat in candy is to transfer milk flavor from milk to candy. Candy flavor is improved more by the addition of milk fat to the candy base than by the use of any other ingredient. Sadler and Wong in Chap. 9 have shown how the flavor of milk fat can be intensified by applying a high heat treatment to make a ghee-like product. A small quantity of this fat added to a vegetable fat candy markedly improves flavor. Milk fat can also cause serious flavor deterioration in

candy. Rancidity due to hydrolysis and tallowiness caused by oxidation is more sharply defined in milk fat than in fats of most other types. Rancidity is usually caused by enzyme action or high acidity in the milk product. When milk fat is allowed to absorb oxygen, oxidation and a tallowy flavor develop. With good quality milk fat the candymaker can rely on the heat treatment used in cooking the candy to destroy enzymes and to produce reducing materials which will protect the milk fat during the normal life of the candy. The heat treatment given to the "ghee" fat described in Chap. 9 greatly prolongs its storage stability. The value of this new milk fat for the candy industry will be determined by commercial trials.

Lecithin is associated with the fat fraction of milk, but when cream is churned, lecithin is concentrated in the buttermilk. Lecithin is an emulsifier and occurs to the extent of 1.6% in dried buttermilk. The emulsifying property of buttermilk makes it especially useful in the manufacture of such confections as milk chocolate and butterscotch.

Formulas For Milk and Whey Candies

Representative formulas are presented in Table 10.3 and 10.4 to demonstrate the use of milk byproducts in the more common types of candy.

TABLE 10.3
MILK CANDY FORMULAS¹

Ingredients	Weight of Ingredients in Lb							
	Pan Caramel	Milk Caramel	Caramel Toffee	Fudge A	Fudge B	Fudge C	Handroll Creams	Marsh- mallow
Sugar (brown for toffee)	32		34	31	78	40	72	55
Corn syrup	32	31	34	22	8	30		24
Invert syrup				3			10	24
Fat ²	10	4	12	1		2		
Dried skim milk	15				6		10	11.5
Sweetened condensed whole		65	20	12				
Sweetened condensed skim						20		
Water	(21)			(5)	(30)		(15)	(38)
Special ingredients		Stabilizer, emulsifier				Coco- nut 3	Inver- tase, citric acid	Gelatin, pectin, inver- tase
Fondant				21.5	8	18		
Frappé	11			9		2	7.5	
Salt				.5			.5	.5
Weight of ingredients except water	100	100	100	100	100	115	100	115

¹A tabulation of the quantities of chief ingredients needed to make some representative candies. For working directions for each candy refer to the text. Add vanilla to each batch to suit the taste.

²Milk fat or the more generally used hardened vegetable fat.

TABLE 10.4
WHEY CANDY FORMULAS¹

Ingredients	"Wheyfer" Ingredi- ents Lb	Whipped Fudge Ingredi- ents Lb	Fudge Ingredi- ents Lb	Caramel Ingredi- ents Lb	Taffy Ingredi- ents Lb
Sweetened condensed whey	84	32	43.0	45	52
Sugar		40	11.0		42
Corn syrup		16	9.0	28	
Invert syrup		5	3.0	6	
Skim milk solids				6	
Hardened vegetable fat			2.5	4	
Milk fat (as butter or cream)				5	
Precooked dry cereal	4		20.0		
Fondant		7	6.0		6
Chocolate			.1		
Powdered lactose (for seed)			5.4	6	
Nuts (optional)	12				
Vanilla to flavor					
Total weight of ingredients	100	100	100.0	100	100

¹The percentages of total candy solids derived from the whey are: "Wheyfers" 40%; whipped fudge 14%; fudge 20%; caramel 21%; taffy 26%.

Many variations can be made in such formulas. Confectioners often use secret formulas which produce candies suitable for their own special markets. Two groups of formulas are given. Those in Table 10.3 require skim or whole milk products while those in Table 10.4 require whey. The frappé of Table 10.3 is the candymakers whipped gelatin or egg white and syrup mixture used to give a light bodied candy.

Procedure in Using Milk Candy Formulas.—(Table 10.3) The caramel and fudge should be stirred during cooking to prevent burning. Water is given in some of the formulas to aid in preparing a homogeneous mixture prior to boiling. When a dried milk product is used, water is generally necessary to disperse it. The plain condensed and evaporated milks contain 64 to 74% water. They may be substituted in the formulas for the sweetened condensed or dried milks, but if this is done the other materials should be combined with only about $\frac{1}{3}$ of the fluid milk product and the mixture started to boil. The remaining milk should be added gradually to the viscous, boiling batch. If this is not carefully done, the milk may coagulate as large objectionable aggregates of curd. The curd particles are difficult to disperse and they produce an unfavorable effect on the appearance, taste, and texture of the candy. For the best results the milk protein must be so treated that it coagulates as very small aggregates. These minute particles of curd form during rapid stirring in a thick or viscous mixture. They are at once protected by a coating of the other candy ingredients and this prevents them from combining with other curd particles to produce a

noticeable coagulum. When a high concentration of milk solids from sweetened condensed or dried milk is used, a viscous mixture is obtained at once. Long boiling to remove excess water is avoided and a spontaneous type of coagulation occurs which produces a soft, flocculent, easily dispersed precipitate or gel.

Varying quantities of fat may be used in the formulas. If a richer candy is desired the fat should be increased. The milk fat may be 12 to 16% for caramels and 16 to 18% for toffee. However, rancidity in high-fat candies is still a problem. The normal fat to msnf ratio preferably should not be changed when one milk product is substituted for another. A vegetable fat may be substituted for milk fat but only by sacrificing quality and flavor. Although data are not yet available the heat treated milk fat discussed in Chap. 9 should improve both flavor and keeping quality.

Either condensed or dried forms of buttermilk and skim milk may be used in the formulas if adjustments are made for the sugar and milk solids content of these products. Blending of ingredients and cooking processes must be conducted in a manner to suit the form of milk byproduct used in the formula. Buttermilk solids contain about 1.6% lecithin, which is useful as an emulsifier in such candies as caramel, butterscotch, or milk chocolate.

Whey should not be substituted for milk in the milk candy formulas. The high lactose and low protein content of whey usually requires that special whey candy formulas be used when whey is to be one of the chief candy ingredients.

Pan Caramel.—(Table 10.3) Mix the sugar and dried skim milk, then add 1 oz of stabilizer (CaO , Na_2CO_3 , or MgO). Gradually add the water to form a paste, then a semiliquid. Heat slowly, then boil and add the fat. Add the corn syrup after the mixture reaches 225° F. Mix in the frappé when the batch reaches the desired firmness.

Caramel, Toffee.—(Table 10.3) Toffee and milk caramels are made by cooking the ingredients to about 245° F, or to the firmness desired. A trace of lecithin or 0.5% sorbitol monostearate may be used as an emulsifier in the milk caramels.

Milk Fudge A.—(Table 10.3) Cook all ingredients together except the fondant, salt and frappé. After the boiling mixture reaches 238°–240° F, cool 3 or 4 min and add fondant, salt and frappé. Cast in starch.

Milk Fudge B.—(Table 10.3) Mix the sugar and skim milk solids, gradually add water, first to a paste, then to a semiliquid mass. Heat slowly to boiling, then add corn syrup and cook to 230° to 235° F. Cool to 170° F, add fondant, mix, add salt and vanilla to taste, pour on oiled paper.

Milk Fudge C.—(Table 10.3) Cook all but the fondant and frappe to 250° F, cool to 172° F, add fondant. When a grain is established by stirring

add the frappé and cool to about 145° F, spread on paper over marble. Setting time 2 hr.

Handroll Creams.—(Table 10.3) Thoroughly mix the dried milk and sugar; then add the water and invert syrup. Heat slowly in a steam jacketed kettle to melt the sugar grain, then boil to a soft ball. While creaming, add salt, vanilla, 3.5 oz of invertase, 2 oz of 50% citric acid solution, and the frappé. Finish creaming, handroll, and chocolate dip. Twelve pounds of dried buttermilk may be substituted for the 10 lb of dried skim milk. Only 6 oz of frappé is needed for the buttermilk creams.

Marshmallow.—(Table 10.3) Dissolve 1.25 lb granulated gelatin in 16 lb cool water, let set 30 min. Heat the following: 24 lb corn syrup and 24 lb invert syrup to 190° F, add 16 lb fine sugar to melt. Cool to 150° F, add gelatin solution. Beat for 20 min, slack back with 40 lb sugar syrup, then add to batch the nonfat milk solution, pectin solution, 2.25 oz invertase, ½ lb salt, and 16 oz vanilla. Marshmallow to be cast with oval top in dry starch. Let set until next day, remove from starch and chocolate dip.

Sugar syrup: 40 lb sugar, 20 lb water, heat to 190° F, cool to 125° F.

Milk solution: 11.5 lb nonfat-dried milk, 20 lb sugar syrup.

Pectin solution: Mix dry ¾ lb sugar, 1.75 oz pectin, add to 2 lb hot water.

Procedure in Using Whey Candy Formulas.—(Table 10.4) The formulas of Table 10.4 are calculated for the use of sweetened condensed whey as the source of whey solids. Plain condensed or dried whey may be substituted for the sweetened condensed product which contains equal quantities of whey solids and sugar (38 to 40% each). When sweetened condensed whey is not used, the quantity of sugar normally included in it may be mixed with the plain condensed or dried whey before these are added to the candy batch. Since sugar aids in the wetting of dried whey, sugar-dried whey mixtures should be prepared and dispersed in water at room temperature. The whey-sugar solution may then be added to the candy mass.

The fudge, caramel, and taffy (Table 10.4) should be cooked in a kettle having a fast double-action stirrer. Water may be added before cooking if necessary to ensure proper mixing. The coagulum formed by whey protein is soft and flocculent. It requires no special treatment during cooking and disperses well in the candy mixture. When whey is the only source of milk protein there is no tendency toward the development of curd lumps or of an irregular rough texture as is sometimes caused by casein coagulation when skim milk is used.

"Wheyfers."—(Table 10.4) Whip the sweetened condensed whey in a mechanical beater for 5 min or more until its volume is at least doubled. The addition of materials containing fat or oil must be avoided, since they destabilize the whip. Spread the nuts on fine-mesh-screen drying

trays. Carefully fold the cereal into the whipped whey and extrude the whip on the screens in ribbons $1\frac{1}{3}$ in. wide and $\frac{1}{4}$ in. thick. Dry the mixture in a tunnel drier at 210° F for about 1 hr. The drying time will depend upon the temperature, the air circulation, and the thickness of the candy. Score, cool, and coat with chocolate to prevent moisture absorption.

Whipped Whey Fudge.—(Table 10.4) Cook the sugar, corn syrup and invert syrup to 272° F, allow to cool to 230° F. Whip the sweetened condensed whey in a mechanical beater for at least 5 min. Mix the cooled syrup, whipped whey, and vanilla, and carefully fold in the melted chocolate. Avoid excessive stirring of the finished mixture. Pour into wooden forms.

Whey Fudge.—(Table 10.4) Cook (with stirring) the sweetened condensed whey, sugar, half the corn syrup, and the invert syrup. The cream or butter may be added after the syrup has been partly boiled down. Cook to 248° F. Cool 25° or 30° or transfer to smaller pouring kettles; add the remaining corn syrup, fondant, and chocolate and stir well for several minutes. Add the powdered lactose, flavoring, and nuts and stir for several minutes. Pour into wooden forms.

Whey Caramel.—(Table 10.4) Cook the ingredients with stirring to about 246° F. The milk products may be added after the syrup has been partly boiled down. Add nuts and flavoring before pouring on a stone slab.

Whey Taffy.—(Table 10.4) Cook the sweetened condensed whey and sugar to 248° F, or higher, if desired; cool, add chocolate, and pull.

Miscellaneous Confections.—The products and byproducts of milk are used in the manufacture of a wide variety of confections. Only a few will be mentioned in this miscellaneous grouping to illustrate some common as well as some unusual candy products. Much could probably be done to develop new and attractive confectionery mixtures that would be useful to the candy manufacturer or that might appeal to the consumer.

Chocolate Products.—Chocolate products contain milk and milk byproducts in accordance with basic definitions and standards promulgated by the Food and Drug Administration (1955) and subsequent revisions. Milk and milk products are also used in many nonstandardized chocolate-like products which are not in semblance of the standardized cacao products. The contents of these nonrestricted products must be stated on the label.

Milk chocolate must contain not less than 3.66% by weight of milk fat and not less than 12% by weight of milk solids. The weight of the nonfat milk solids must be not more than 2.43 times and not less than 1.20 times the weight of milk fat. This in effect requires that milk chocolate be made from a whole milk product or its equivalent in terms of fat and solids. Dried or sweetened condensed whole milk may be used for chocolate manufac-

ture. The condensed milk product should be low in moisture, hence specially prepared sweetened condensed milks of 75 to 80% solids or even higher are sometimes made.

Skim milk chocolate contains less than 3.66% of milk fat and not less than 12% of skim milk solids. Buttermilk chocolate contains buttermilk solids in place of skim milk solids. Dried sweet cream buttermilk can be used as an emulsifying ingredient. Mixed dairy product chocolate is made from various dairy ingredients and contains less than 3.66% of milk fat and not less than 12% of milk constituent solids.

An important phase of milk chocolate manufacture is the mixing and blending of ingredients. The milk products and chocolate are intimately blended by a conching or mixing operation that results in a coalescence of particles and the formation of a smooth homogeneous structure. A full development of milk flavor occurs during conching. Sweetened condensed milk products are well-suited to chocolate manufacture since they merge with other ingredients to yield a smooth mass of proper viscosity and pronounced milk flavor.

Milk Chocolate Crumb.—Milk chocolate crumb is a mixture of milk solids, sugar, and chocolate liquor or cocoa. It is a candy ingredient and represents an intermediate step between the raw materials and finished chocolate coating or chocolate candy. Milk chocolate crumb is manufactured by large chocolate producers as a means of developing characteristic milk chocolate flavor and for the storage of intermediate materials needed for candy production (Woollen 1964). There is little published information concerning milk crumb and its production has usually been held secret.

Milk crumb is manufactured by the concentration and drying of a mixture of whole milk, sugar, and suitable cocoa products. Chocolate liquor and/or cocoa is added to the milk-sugar mixture during evaporation. Cocoa butter is usually added during refining of the crumb and conching to make finished chocolate. A typical composition of the finished crumb may be considered to be: milk fat 8%, msnf 16%, sucrose 48%, cocoa 13%, and cocoa butter 15%. The milk solids are generally in the ratio found in whole milk.

Milk crumb shows unusual flavor stability. As the dried mixture ages, usually in a large silo, flavor is improved and contrary to what might be expected the milk fat does not become oxidized. Milk crumb may be held at least six months at room temperature without flavor deterioration. The cocoa bean apparently contains a far more effective antioxidant for milk fat than can be found from any other known source. The active antioxidant appears to reside in the cocoa butter fraction but there also remains a reserve in the cocoa itself when the fat is removed by pressing. Even a low-fat

cocoa product still retains, and can impart to other fats, some antioxidant effect.

Details of the processing of the cocoa bean have been the secret of a few large companies. The bean is roasted, broken or winnowed to separate the shell, and this produces the nibs which are broken pieces of beans. These are roasted, pulverized, ground or refined to produce the liquid called mass or cocoa liquor. The composition of the mass is 54% cocoa butter and 46% fat-free cocoa. Cocoa is produced from pressing the mass and it contains from about 10 to 24% fat. Even low-fat cocoas are high in natural antioxidants. The extracted fat-free cocoa is mostly a waste product but still carries residual antioxidant properties. The milk fat of milk crumb does not oxidize readily because of the strong reducing power of the milk crumb. Saunders (1957) has shown that mixtures of milk solids and defatted chocolate liquor have the property of strongly reducing potassium ferricyanide; whereas, mixtures of milk solids and sucrose are weakly reducing, and defatted chocolate liquor and sucrose do not show a reducing property. Saunders concludes that the reactions between the ingredients in the manufacture of milk crumb involve a complex formation or combination between the milk solids and the chocolate liquor which reduce potassium ferricyanide. Apparently, it is this strong reducing complex which inhibits the oxidation of the milk fat in the crumb. Isolation and identification of this complex and its addition to dried whole milk might delay the rapid oxidation of milk fat in dried milk.

Chewing Gum.—Chewing gum is made from a blend of several kinds of chicle flavored to suit the taste. Sweetened condensed milk is often used in chewing gum in quantities up to about 5% of the weight of the gum. The condensed milk improves flavor and aids in body development. Chicle itself is rubbery but the addition of sweetened condensed milk makes it softer and more pliable and prevents the gum from breaking down excessively in the mouth.

Fountain Syrups.—Fountain syrups for topping ice cream are made with various forms of milk products. A hot fudge topping may be prepared by first mixing 4 lb of sugar, 14 oz of cocoa and 1 gal. of milk, or 12 oz of dried skim milk plus 3 qt of water. Boil the mixture 10–15 min until smooth. Dissolve 1 oz of cornstarch in 1 pt of cold water and stir slowly into the chocolate mixture. Add 3 oz of butter (5 oz if dried skim milk is used) and heat with stirring until desired thickness is reached. Strain if mix is not smooth. Add vanilla to taste.

Caramel topping may be made by mixing 10 lb of sugar, 3.75 lb of dried skim milk, 5.5 lb of water, and 10 gm of a stabilizer (CaO , Na_2CO_3 or MgO) to form a smooth semiliquid mass. Heat to boiling with stirring and

add 10 lb of corn syrup, continuing to boil the batch 218°–220° F. Salt, vanilla, and butter may be added to taste.

An excellent syrup or topping may be made by mixing a chocolate, caramel, coffee, or other flavored nonacid base with a sweetened condensed milk product. Sweetened condensed whole, skim, buttermilk, or sweetened condensed whey may be used. The quality of the topping will depend in large measure upon the quality of the sweetened condensed product. The flavor base can be made with little or no milk, but it should contain a sugar in water concentration of 60%. Mixtures of various quantities of flavor base and sweetened condensed product may be prepared to suit flavor and viscosity requirements. It is not necessary to cook the topping since each component contains enough sugar to inhibit bacterial growth. Since the sweetened condensed product is not cooked it is capable of transferring a full milk flavor to the topping. A viscous but stable sweetened condensed product in which the lactose crystals are small and uniform in size is required.

Peanut Butter–whey Mix.—A mixture of equal parts of peanut butter and sweetened condensed whey will produce an attractive sweet filling or candy center. It may also be used as a sweet spread. The addition of sweetened condensed whey takes the sticky, clinging characteristic from peanut butter and gives it a smooth, short type of body. The mixture is prepared by blending one pound of sweetened condensed whey for each pound of peanut butter to be treated.

Fruit Mixtures.—Sweetened condensed whey may also be mixed with various fruit jams for use in spreads or toppings. The physical qualities of such mixtures are satisfactory since the fruit acid will not coagulate the whey protein. However, as is often the case with whey mixtures, the fruit flavor is diluted by the whey and is inferior to the flavor of the original fruit.

An apple-milk confection that will utilize surplus and cull apples has been prepared by mixing pulped apples and skim milk and drying the mixture on a vacuum drum drier (Vilbrandt and Sieg 1941).

Milk-honey Confection.—Milk-honey confection, a candy developed by Iverson (1937) is made by drum drying a mixture of 100 lb of whole milk and 9.4 lb of honey. The milk is pasteurized at 170° F, homogenized, cooled to 60° F and mixed with the honey. The mixture is dried on drums 28 in. in diameter revolving at 12 rpm and maintained at 270° F. The plastic mass is scraped from the drums, formed into bars and chocolate coated. The low moisture content of the product and the presence of the invert sugar in the honey are effective factors in keeping the lactose in an amorphous, noncrystalline condition.

Dried Honey-skim Milk Mixture.—Dried honey-skim milk mixture is a powder that may be pressed to yield an attractive honey-flavored wafer or that may be used as a source of honey and milk solids in candy manufacture or for the preparation of other foods, including dry mixes and bakery goods (Walton *et al.* 1951). This product was developed to fill the need of food manufacturers for a dried honey. The mixture is prepared by either of two methods. Equal parts of honey and concentrated skim milk (35% solids) on a solids basis are spray dried by conventional methods. This mixture is hygroscopic and difficult to handle.

A second and better process for preparing a dried honey-milk mixture is to pour, drip, or spray honey slowly into dried skim milk with constant, slow agitation. A product containing 50 to 60 parts of honey solids to 40 to 50 parts of skim milk solids can readily be made. The honey droplets immediately become surrounded by a coating of dried skim milk. Spray-dried milk in which the lactose is amorphous must be used. After the honey has been stirred into the milk powder, the mix should be seeded with lactose and dextrose and spread on trays. Both the lactose from the milk and the dextrose from the honey crystallize with absorption of one molecule of water obtained from the moisture of the honey. If the mixing has been properly done a light powder will result.

Crystallization may continue for an hour or more after which the product may be dried in the trays to insure good keeping quality. Although the lactose and dextrose of the mixture are crystallized, the levulose of the honey remains amorphous and capable of some water absorption.

Indian Confections

Milk and certain indigenous dairy products are used extensively in the manufacture of the special confections found throughout India. Ghee, or Indian milk fat, is prepared by heating country butter to temperatures as high as 240° F and separating the fat. A continuous process for making ghee is described in Chap. 9. Ghee is used as a component of many native candies. Several milk preparations of a concentrated nature that might properly be considered as byproducts are also used either in confections or without further processing, as sweets themselves. Detailed information on native Indian products may be obtained from a pamphlet by Davies (1940). There are many other Indian studies.

The fluid milk of India is often produced and handled under unsanitary conditions. To safeguard this milk against spoilage and to protect the health of the people, bulk milk is boiled before it is used. This habit of boiling the milk no doubt led to the development of the native milk products, most of which are prepared on a domestic scale by drastic heat treatments.

TABLE 10.5
APPROXIMATE COMPOSITION OF INDIAN MILK PRODUCTS USED AS
CONFECTIONS OR IN THE MANUFACTURE OF CONFECTIONS¹

Product	Treatment While Heating	Protein %	Fat %	Lactose %	Ash %	Sucrose %	Water %
Channa	Acid precipitation	18.5	32.5	2.3	0.3	—	46.5
Malai	Surface skimming	3.2	28	3.4	0.4	—	65
Rabbri	Surface skimming	9.5	19	16.0	3.0	25	28
Kheer	Evaporation	9.0	17	14.0	2.4	20	38
Khoa	Evaporation	18.0	36	30.0	5.0	—	11
Khoa ²	Evaporation	24.5	27	20.0	4.0	—	24.5

¹This table was compiled largely from data by Davies (1940).

²Suggested minimum standard (Iyer *et al.* 1948).

The preparation of Indian confections is a secret art which is practiced by individual specialists. The candies may contain some form of milk product, cereal, and sugar. The ingredients are cooked as small batches in open kettles. Individual characteristics in the confections are developed by variations in type and quantities of materials, cooking conditions, and physical manipulations. The composition of some concentrated Indian milk products used for confections is given in Table 10.5. Actually there are wide variations in composition and methods of preparation but the values of Table 10.5 may be considered as representative of average products.

MEAT PRODUCTS

Concentrated forms of milk, usually dried skim milk, may be used in the manufacture of special meat products and meat substitutes. Meat products designed for interstate shipment must conform with the requirements of the meat inspection service (Bureau of Animal Industry 1947). The total cereal, starches, and nonfat milk solids must not exceed 3-1/2% of the weight of finished sausage. Meat loaves are made with either pork or beef and the limit for added moisture is 3%. This imposes an automatic limit on the quantity of milk solids that can be used. Excessive amounts of skim milk will produce a dry crumbly loaf. Usually each pound of nonfat milk solids will absorb 1 lb of water. A third class of meat product may be labeled "Loaf" followed by a statement of the optional ingredients it contains. These are known as "non-specific loaves." A "Loaf" may contain any quantity of skim milk solids but if more than 12% is used the meat flavor will be very weak. Meat substitutes must be properly labeled with a statement of ingredients as required by the Federal Food, Drug and Cosmetic Act.

Skim milk solids compare favorably in nutritive value with the types of meat used in sausage and meat loaves. Dried skim milk contains about 36% protein while the grades of beef, pork and veal used for sausage contain ap-

proximately 53, 13, and 69% protein, respectively. There probably is little difference in the relative nutritive values of the meat and milk proteins.

The presence of skim milk solids apparently has a tendency to aid in the development of an "off" or stale flavor during the storage of bulk or loaf sausage but this does not occur in those meat products that are filled into casings and processed.

The chief physical function of skim milk in chopped meat products is that of taking up water and at the same time contributing to the production of a firm texture. Skim milk solids contain about 28% protein and bind water pound for pound. Where its use is permitted 1 lb of sodium caseinate will bind 4 lb of water. During cooking in the presence of the other sausage constituents the casein absorbs water. The resulting finely dispersed curd blends well with the chopped meat and helps to bind it together to produce a smooth but chewy meat-like texture. This reduces crumbling, improves slicing properties, and cuts down shrinkage during storage. Certain cereal products may be capable of greater water absorption but the water absorbing properties of skim milk are ample for good quality sausage. From considerations of the effect on nutritive value, flavor, texture, and water binding capacity, skim milk solids can be considered better for use in sausage and meat loaves than cereal products.

Preparation of Meat Products

Little information is available on the actual processes used in the preparation of sausage, meat loaves, and related products. The primary object in manufacturing these foods is to make a nutritious and attractive food from what is usually regarded as an unpalatable part of the animal carcass. The processing generally consists of mincing or grinding the meat, mixing the water absorbing agent (cereal or milk byproduct) and seasoning with it, molding the mixture or filling it into casings, and cooking the product (Read 1949; American Meat Inst. 1953).

Flavoring with spices, herbs, and various seasoning materials is a very important part of sausage manufacture. In some parts of England, for example, strong sage and thyme flavors are preferred while in other parts cayenne pepper or cinnamon are favored (Read 1949). Continental sausages are made with a variety of flavorings such as peppers, nutmeg, mace, cinnamon, and thyme. They are processed to produce certain delicate and characteristic flavors.

The nonmeat ingredients may consist of one or more cereals such as wheat rusk, wheat flour, farina, barley, oatmeal, or rice. Milk byproducts are highly favored members of the nonmeat, water absorbing group of ingredients.

Sausages are usually cooked in smoke houses or in special steam heated

chambers. Care must be taken to control the process so as to avoid bursting of the sausage casings. The canned meats are cooked in the usual type of pressure autoclave.

Smoked and cooked sausage such as bologna, salami, and frankfurter are treated according to the results desired. The meat mixture is cured with sodium nitrite and salt, stuffed into casings, and smoked. Cooking is then done by heating in the smoke house until the interior of the sausage reaches 160°–180° F.

Formulas

The following formulas taken from a group of 65 published by the American Dry Milk Institute (Pahlke 1942) will serve to illustrate the use of milk solids in meat products:

Frankfurter			
	Lb		Oz
Veal trimmings	45	Mace	2
Bull meat	20	Ground mustard	4
Pork trimmings	35	Onion powder	1
Nonfat milk solids	4.5	Garlic	1.25
Salt	3	White pepper	7
Water	36	Paprika	2
1 qt Cure		Sheep casings	

The cure consists of a mixture of 3 lb 7 oz sodium nitrate, 5 oz sodium nitrite and 10 lb of dextrose made up to 5 gal. with water. The batch is smoked 1.75 hr at 130°–175° F, cooked, and cooled. The loss in weight during processing is 9%.

Liverwurst			
	Lb		Lb
Hog livers (scalded)	40	Nonfat milk solids	4
Hog gut fat (scalded)	15	Onions (fresh peeled)	4
Cook until tender:		Salt	3
Hog tripe	15	White pepper	6 oz
Hog skins	20	Sweet marjoram	1.5 oz
Beef tripe	10	Ground cloves	½ oz

Cook skins and tripe slowly in water and remove; scald livers and fat in same broth. Cut skins, add liver, tripe, and onions and chop; then add fat, nonfat milk solids, and spices; chop until fine, mix with broth, and stuff in beef rounds. Cook 30 min, chill, and hang to dry.

Roast Beef Loaf

	<i>Lb</i>		<i>Oz</i>
Fresh beef	100	White pepper	8
Grated onions	2	Ground bay leaves	2
Tomato catsup	10	Worcestershire sauce	3
Salt	3		
Nonfat milk solids	12		

Cut meat in $\frac{1}{2}$ -in. pieces, cover with water in steam jacketed kettle, bring to boil, add all ingredients except skim milk; cook until tender. Place meat in mixer with nonfat milk solids and add 45–50 lb of cooking broth, mix, place in pans, and chill.

MEAT SUBSTITUTES

Many attempts have been made to utilize milk protein in the preparation of meat substitutes. These trials appear to have met with little success, judging from the scarcity of published results, or of commercial production of actual products. Two characteristics, the flavor and texture of meat, have not yet been produced successfully by processing milk protein. There is little difference, however, in the nutritive value of the meat and milk proteins.

The appealing odor and flavor of cooked meat cannot be developed by any known treatment of milk protein. Sodium glutamate, a product of casein hydrolysis, has been said to have a meat-like odor. However, its addition to a variety of animal and vegetable products has shown that rather than contributing a flavor of its own, sodium glutamate tends to intensify the natural flavor of the food to which it is added. The products of casein hydrolysis can be successfully used in gravies or meat sauces but they do not contribute meat flavor in the absence of meat.

The texture of meat has not been duplicated in any kind of milk protein preparation. However, processes have been developed which produce in casein the chewy, structural properties that are characteristic of chopped meats or hamburger. An approach to this kind of texture is made in the preparation of cottage cheese. Both casein and soy proteins have been precipitated and extruded in a form which simulates ham and chicken. A fibrous product has been prepared by immersing spun casein in a bath of treating fluid, vibrating the fluid and product to separate the fibers and impregnating them with the fluid (Dechaine and Callaghan 1967).

Dried skim milk can be added successfully to meat-type loaves in rather large quantities but meat should be present to give flavor. Cooking will

cause the milk protein to coagulate, absorb water and help to produce a firm texture. Such products must be properly named and labeled.

ION EXCHANGE PRODUCTS

The Zeolite process of softening hard water is a relatively old one but the application of the ionic exchange principle to milk products was first made by Lyman (1934). At that time the milk products were brought in contact with various base-exchange silicates but in recent years carbonaceous and synthetic resinous exchangers have been developed. Lyman's early work was chiefly concerned with the removal of both calcium and phosphate ions from milk to produce a soft curd product. New exchange materials can now be used to alter the ionic equilibria of milk and whey products. Garrett (1948) has presented a simple explanation of the ion exchange process and has shown its application to dairy processing. Many papers on various phases of ion exchange have appeared in the chemical journals. Smith (1957) has briefly reviewed the modification of milk composition and the preparation of milk products by ion exchange.

There are two general types of ion exchangers. The cationic exchanger exchanges its own positive elements, such as sodium, calcium, magnesium, or hydrogen for cations in the solution which is passed over it. The anionic exchanger exchanges its negative radicals, such as chloride, sulfate, phosphate, citrate, or hydroxyl ions for anions in solution. An amine type of resin apparently combines chemically with most acid molecules.

Ion Exchange Procedures

Processes for treating milk and whey and for regenerating the exchangers are available. Treatment may be by either of two methods. The batch process consists in mixing the milk and exchange material, then separating them by filtration. The column process involves passage of the milk through a column or bed of the exchanger.

Use of Synthetic Inorganic Exchangers.—During some of the early work natural greensand was found to be unsatisfactory for the treatment of milk. However, a hydrated synthetic sodium aluminum silicate known as Crystalite showed a high capacity for calcium removal, uniformity, and purity. It is possible to use Crystalite daily for more than a year with but little replacement. It will treat 125 gal. of milk per cu ft of exchange material. Milk can be produced which is uniform in color, flavor, acidity, and curd tension. Approximately 20% of the calcium and phosphorus present in the milk is removed by the sodium aluminum silicate. Milk, to be treated for removal of calcium and phosphorus, is carefully acidified at 50° F with citric acid to produce a titratable acidity of 0.25 to 0.35% but without the development of a coagulum. It is then passed through the ex-

changer and the removal of calcium and phosphorus is accompanied by a reduction to normal acidity.

Use of Organic Resin Exchanger.—Haller (1950) investigated both the use and regeneration of synthetic organic resins when applied to the alteration of the ionic equilibrium of milk and whey. Extensive work to remove strontium 90 from milk without adversely altering its gross composition or flavor was summarized by Edmondson (1964) for a laboratory operation and by Walter *et al.* (1967) for pilot plant use. References to preliminary papers and complete operating directions were given.

For calcium, or calcium and phosphate removal a cation exchanger of the sulfonic acid type is used. The amount of calcium that can be removed is dependent upon the exchange capacity of the resin. The methods used for regeneration of the resin determine what ions will be removed and the resulting effect on the pH of the milk. The reaction of the milk must be returned to its pretreatment value by chemical means or by a compensating ion-exchange treatment.

The fixed-bed process for removal of radiostrontium from milk includes the following operations (Edmondson 1964). A nuclear, sulfonic acid-type resin bed is charged with a mixed solution of calcium, magnesium, potassium, and sodium chlorides. The quantities are chosen so that the resin and milk will be in equilibrium with respect to these cations. The cold milk is acidified to pH 5.3 to ionize the strontium and then flowed through the column. The effluent milk is neutralized by continuous in-line addition of a solution of hydroxides, preferably potassium. After neutralization the milk is pasteurized and homogenized. Approximately 95% of the strontium is removed.

Ion Exchange in the Processing of Milk Products

The ionic equilibrium of milk products can be adjusted by standardization with ion-exchange-treated skim milk or whey. The addition of suitable amounts of one of these treated byproducts to a mixture during processing can strikingly affect certain properties of the finished product. The treatment of whole milk involves certain mechanical and technical difficulties that result in the loss of milk fat in the filter beds. The ion-exchange treatment of whole milk can usually be avoided by standardization with treated skim milk.

Uses for Ion-exchange-treated Skim Milk.—*Soft Curd Milk.*—Skim milk that forms a soft curd suitable for infants may be produced by reducing the CaO and P₂O₅ values of a stock supply by about 30%. Standardization of special milks with the treated skim milk effectively produces a soft curd milk with a low curd tension.

“Sandiness.”—Sandiness due to crystallization of lactose in high milk solids ice cream has been retarded by the use in the mix of a skim milk of low calcium phosphate content (Otting and Quilligan 1941). About 30% of the calcium and 20% of the phosphate of the milk was removed. Ice creams that contained 16% base-exchange-treated msnf did not develop sandiness during storage.

Evaporated Milk.—Evaporated milk can be stabilized toward heat by adding ion-exchange skim milk to it before sterilization (Josephson and Reeves 1947). The skim milk may be prepared by passing it through a resinous cation exchanger to remove 60% of the calcium. Since this increases the reaction of the milk to about pH 8.0 it should be adjusted back to pH 6.6 by means of a hydrogen exchanger. The skim milk then may be used in fluid, concentrated, or dried form. The low-calcium skim milk may be added to the batch of evaporated milk at any stage prior to canning of the evaporated product. Such an addition may be used in place of the customary phosphate salts to stabilize evaporated milk during sterilization. Evaporated milks requiring 2 to 7 oz of disodium phosphate per 1,000 lb of concentrate to produce proper heat stability can be similarly stabilized by treating 0.5 to 2.5% of the original milk by the ion exchange process or by standardizing the batch with this quantity of base-exchange concentrate.

Cream.—Cream may be stabilized by ion-exchange treatment of the skim milk with which it is subsequently standardized (Garrett 1947). The skim milk is subjected to cationic-exchange material acting in the alkali-metal cycle. This removes 60 to 70% of the calcium and gives the milk an alkaline reaction which must be corrected by passage through a hydrogen exchanger. The skim milk is then ready for standardizing cream. Through its use the calcium-phosphorus ratio should be reduced from the 1.2 of normal milk to between 0.5 to 0.75. Such stabilized cream may be standardized and dried. The fluid or dried stabilized cream will not feather, coagulate, or oil off in hot coffee. It will not curdle when it is added to acid fruits, when it is used in creamed soups, or when it is boiled in caramel manufacture. Any drastic alteration of calcium-phosphorus ratios or large reductions of these elements in milk could be considered nutritionally objectionable.

Low Sodium Milk.—Foods low in sodium have appeared on the market in recent years, among them low sodium milk. Milk low in sodium is prepared by treatment of fluid milk by ion exchangers according to several different processes which have been reviewed by Smith (1957). Early work was done with an ammonium cation exchanger with both sulfonic and carboxylic types of cation exchangers or with a cation exchanger in the potassium cycle. For the most part these treatments tended to produce some changes in taste and appearance of the milk. One procedure which

avoids changes in flavor consists of maintaining the original calcium content of the milk while removing the sodium. To do this, milk may be treated by a potassium cation exchanger which removes both the sodium and the calcium, the calcium being later replaced. By another procedure the pH of the milk is raised to reduce calcium ionization and prevent its removal by the potassium cation exchanger. A third method is to regenerate the cation exchanger with a mixture of calcium and potassium salt in the right ratio of calcium to potassium so that the calcium on the exchanger is in equilibrium with that in the milk, thus permitting only the sodium to be exchanged.

Low sodium milk was a subject of a statement by the Council on Foods and Nutrition (1957) which presented data averaged from seven different commercial milks. The Council concluded that 90% of the sodium had been removed from these milks; that potassium was increased almost twice; that thiamine, niacin, and vitamin B₁₂ were reduced by 50%; and that calcium and vitamin B₆ were reduced by 75%.

Casein.—Casein suspensions may be treated with a base exchange material to produce a soluble sodium caseinate of low calcium and phosphorus content. Sodium caseinate may in turn be precipitated by acid to yield a casein low in calcium. For most casein uses the product prepared by the usual acid precipitation is quite satisfactory and less expensive.

Ion-exchange-treated Whey Products.—A new approach to the recovery of substantially all the lactose in whey was made by Almy and Garrett (1949). Skim milk or whey was treated with exchange material in the hydrogen cycle to reduce the reaction to pH 4.6–4.8. The protein was coagulated by heating to 175°–210° F and then removed. The whey was again contacted with exchange resin in the hydrogen cycle to reduce the reaction to pH 1.6–1.8. This treatment removed 90–95% of the metal ions. The demineralized whey was next passed through an anion-removing exchanger to raise the reaction to pH 7.5 to 9.0. After adjustment of the reaction to about pH 6.6 the liquor was concentrated and dried. The finished product contained 95.2% lactose, 2.6% noncoagulable protein, and 0.8% ash.

Ion-exchange treatment of whey might be useful in the conventional processes of lactose manufacture were it not for the cost. Seventy to eighty percent of the nonprotein nitrogen in deproteinized whey can be removed so that the lactose remaining can be more readily concentrated and crystallized.

A demineralized, deacidified whey, useful in food manufacture, was prepared by Meade and Clary (1949). Whey was subjected to repeated cycles involving successive contacts with a decationizing medium and a deacidifying medium. The flow over the different resins was so regulated that

the reaction of the whey during treatment remained within the limits pH 3.8 to 7.5. The modified whey was concentrated or dried. It contained: moisture 1.6%, acid 0.2%, lactose 84.5%, protein 11.2%, and ash 3.3%. The whey was useful for the preparation of infant or special milks and milk concentrates, to which it imparted heat and storage stability.

MARGARINE

Margarine is composed largely of vegetable oils and some animal fats emulsified with skim milk, milk, or cream. It may, or may not also contain a special emulsifier and starter distillate with other flavoring ingredients. Milk fat is rarely used in margarine but all manufacturers rely upon emulsifying their oils with nonfat milk solids. Skim milk is used in the fluid or dried form. Dried skim milk has the advantage of being easily shipped, stored, and handled and it may be made up to a higher solids content than fresh skim milk. The skim milk to be used in margarine is pasteurized and cultured with a lactic starter to develop about 0.7% titratable acidity. Approximately 80% vegetable oil, 18% skim milk, and 2% salt are used. The msnf of the finished product may vary from 1.8 to 3.0%. The emulsion is prepared at 110° F, then chilled to 35° F to form the margarine.

Four general methods of margarine manufacture are in use:

(1) The wet method. The oil and skim milk are proportioned into a mixing conveyer, then dropped into a tank of water held at 35° to 40° F. The quick chilling crystallizes the fat into granules after which the margarine is tempered, printed, and packaged.

(2) Refrigerated drum method. The oil and skim milk are premixed and dropped onto refrigerated double drums similar to the type of drum used to dry milk. The thin sheet of emulsified oil hardens on the drums as it cools to 35° F during one revolution of the rolls. The margarine is scraped from the drums, tempered, and formed into prints at 40° F.

(3) Continuous chilling method. The oil-skim milk mixture is emulsified and continuously chilled by forcing it through a machine similar to the continuous ice cream freezer. The margarine emerges from the chiller ready to print.

(4) Churning. The oils and skim milk are emulsified to produce a cream-like product which is cooled and churned just as butter is churned. When the emulsion breaks the margarine is worked and printed.

DRESSINGS

A recently promulgated definition and standard of identity for mayonnaise, French dressing, and salad dressing excludes milk products from the list of permissible ingredients that may be used in the manufacture of these

foods. However, milk products have been included among the ingredients of nonstandardized dressings for food. Care must be exercised to label such a dressing in a way that will not represent it as one of the defined products mentioned above. Egg yolk is the only emulsifying agent used in mayonnaise and it has never been equaled by any milk product.

Soluble whey protein has been used as a whipping and emulsifying agent in dressings for salads. The product must be concentrated and preferably some of the milk salts removed.

When the newer methods of treating whey by electrodialysis, gel filtration, or reverse osmosis become economical whey protein preparations should become available for many new food uses.

Dried skim milk may be used as an ingredient for dressings for salads. When skim milk of 25 to 30% solids content is whipped for a few minutes a stiff white foam is formed. The foam can be set by the addition of acid from vinegar or fruit juice, but subsequent disturbance of this whip will cause wheying off. Foams set with a stabilizer have greater stability.

Sour cream in dehydrated form is used in making an assortment of non-standardized dressings for foods.

SIMULATED MILK PRODUCTS

Simulated milk products may be made with or without some of the components of milk. Usually skim milk or sodium caseinate is combined with fats from vegetable sources. When sodium caseinate is the protein source carbohydrate from corn syrup or lactose may be used. Simulated products have had limited success even when they have been made with attractive flavor and at a lower price than dairy products. In countries where dairy products are not available and where there are ample supplies of vegetable components, simulated mixtures can be important in easing cases of acute malnutrition. The use and role of filled milk in the Philippines has been studied (FAO 1962). The nutritive quality of simulated milk mixtures made from vegetable products was studied recently (Standal and Kian 1968). When there is sensitivity to cow's milk, replacement with a non-milk, nonallergenic product often provides satisfactory nutrition. Products for milk intolerance are discussed later in this chapter.

There has been renewed interest in simulated milk products due to their commercial production and marketing in competition with real products. Substitutes for dairy products are of two general types: (1) those that use one or more components of milk as an ingredient, and (2) those without milk components. Both must have flavor, texture, nutritional value, palatability, and appearance similar to natural dairy products and their prices must be significantly below those of their dairy counterparts if they are to be commercially successful.

Legal Status of Simulated Products

Terminology to be applied to the simulated products, as well as their legal status is still unresolved. Standards of identity and quality have been proposed for imitation milks and creams (Food and Drug Administration 1968). These imitation products are the foods made in semblance of skim milk, low-fat milk, part-skimmed milk, milk, and high-fat milk in single strength liquid, concentrated, dried, or frozen form, or Half and Half (milk and cream) in liquid form containing one or more of a group of optional ingredients. Among these optional ingredients are casein, salts of casein, milk proteins (coprecipitates of casein, lactalbumins, and lactoglobulins), whey, whey modified by partial or complete removal of lactose or minerals, or both, and lactose. Except for violation of the Filled Milk Act it would be expected that skim milk would be included in this latter grouping. Thus imitation milk resembles milk, but one or more of the classes of milk components have been replaced by nonmilk derivatives usually of vegetable origin. Substitution of vegetable fat for milk fat is the most common type of imitation and is economically the most attractive.

By definition: "The term 'filled milk' means any milk, cream, or skimmed milk, whether or not condensed, evaporated, concentrated, powdered, dried, or desiccated, to which has been added, or which has been blended or compounded with, any fat or oil other than milk fat, so that the resulting product is in imitation or semblance of milk, cream, or skimmed milk, whether or not condensed, evaporated, concentrated, powdered, dried or desiccated. This definition shall not include any distinctive proprietary food compound not readily mistaken in taste for milk or cream or for evaporated, condensed, or powdered milk, or cream . . ." (Christopher and Dunn 1954). This act bars "filled milk" from interstate commerce but filled products are legal in some states.

The laws of the various states differ but many permit the manufacture and sale of imitation dairy products. These may use one or more components of milk as ingredients or they may use no milk product in their manufacture.

Dairy Ingredients for Simulated Products

Milk fat has no place in an imitation or filled milk product. Indeed, the whole concept of simulated products is designed to replace expensive milk fat by inexpensive vegetable fat. No wholly adequate substitute for milk fat is known, so that the resulting simulated products using vegetable fat are deficient in flavor even though their structural characteristics resemble the actual product. Just as there is no fully adequate substitute known for milk fat so also there is no satisfactory substitute for the protein fraction of nonfat milk solids. Lactose may be replaced by corn syrup solids or

other forms of carbohydrate having a high percentage of dextrose. A mineral mixture can be compounded which could be nutritionally satisfactory. It is particularly important that the calcium and phosphate content of a simulated milk approach that found in the real product. Vitamins and necessary nutritional factors can also be added to attain the proper level. However we still lack the knowledge necessary to compound a nutritionally adequate substitute for all the basic components of milk.

Milk Protein for Simulated Products.—The only completely satisfactory protein for simulated products is milk protein. Whey protein because of its limited supply and lack of availability free from excessive amounts of lactose and minerals is not often used. Sodium caseinate is the protein of choice because of its ready availability at a reasonable price and because of its pleasing, mild flavor.

Fresh Skim Milk.—Fresh skim milk is the best source of milk protein for production of a simulated whole milk or of other imitation or filled products. While good quality condensed or nonfat dried milk may be used, the fine delicate flavor of fresh dairy products is best recaptured by fresh skim milk. Skim milk furnishes all of the desirable milk components except the fat.

Sodium Caseinate.—Sodium caseinate has been considered by the Food and Drug Administration as a chemical derived from milk rather than as a dairy product. This protein can therefore be used in conjunction with a vegetable fat to produce an imitation milk product that is acceptable in interstate commerce. The term "nondairy" applied to such products may be a misnomer. The manufacture of sodium caseinate is discussed in Chap. 11. Sodium caseinate tends to acquire an old, gluey or storage flavor when it is held at room temperature for storage periods of a few months. To avoid transferring such flavor to simulated milk products, sodium caseinate is often prepared from casein shortly before it is to be used in the substitute products. Sodium caseinate when fresh is of mild pleasing flavor and it shows excellent water holding properties. It can be dispersed rapidly in aqueous mixtures, and when a vegetable oil is homogenized into it a stable emulsion is formed. Sodium caseinate produces a desirable body in such "nondairy" products as imitation sour cream, coffee whitener, imitation egg nog, chocolate drink, frozen desserts and whipped topping. The quantity used on a solids basis may vary from about 5% for whipped topping to 9% for coffee whitener.

Whey Protein.—The protein content of whey is so small, about 0.8%, that it usually is not profitable to recover it for use in simulated products, even though it is precipitable from whey by heat and salts. However, coprecipitates of casein and whey protein are being sold for use in simulated

products. Coprecipitation increases the yield of milk protein from skim milk by about 16%. To precipitate the whey protein with casein it is only necessary to heat coagulate the whey protein fraction before the precipitation. This may be done by heating the skim milk to 180° to 200° F, cooling it, readjusting the salt balance if necessary by the addition of calcium, and precipitating the coprecipitate by rennet and/or acid.

Substitute Protein for Simulated Products.—Fully satisfactory vegetable or fish protein is not yet available for use in simulated products. In their present state of development they are deficient in nutritive value and they do not have the physical and flavor characteristics of milk protein. Srikanthia and Gopalan (1966) studying fish protein concentrate in treatment of kwashiorkor found it inferior to skim milk even when it was supplemented with lysine. Fish protein was not accepted by some children and it failed to promote body weight gains. Continued research may find a way to overcome flavor and nutritional deficiencies in the vegetable and fish proteins.

Proprietary Protein Mixtures.—These may contain protein, emulsifier stabilizer, and flavor. They are prepared especially for making simulated products. To produce the desired product the composite protein base need only be mixed with the proper kind and amount of fat. The mixture must be pasteurized, homogenized, and cooled. Another type of proprietary product consists of a blend of a protein product with vegetable fat emulsifier and stabilizer. Depending upon the blend used and the product to be made, water, skim milk, sucrose, dextrose, corn syrup solids, or other material must be added to attain the product objective. Suppliers make almost any combination of ingredients that might facilitate the preparation of a simulated protein-fat containing dairy product.

Fat for Simulated Products.—The one dairy ingredient which does not appear in simulated products is milk fat. The replacement fat must be inexpensive, mild in flavor, or flavorless, and possess the physical attributes of butterfat. It has been possible to prepare vegetable fats tailored so closely to specific product needs that the finished item may have even more desirable physical characteristics than the real product. The desired fat is emulsified in an aqueous phase which usually contains casein representative of the skim milk fraction. The fat must be carefully dispersed in the aqueous phase to produce an acceptable body and texture.

Strangely, legal restrictions have thus far made it impractical to adjust the physical properties of milk fat to the requirements of improved products. Thus, desired body characteristics have not been fully met in some real products. Substitute fats can be altered or blended to produce exactly the kind of body or texture desired in the imitation item. Vegetable fats with suitable melting points and crystallization habits are selected. Fats

TABLE 10.6

SOLID FAT INDEX (SFI)¹ AT VARIOUS TEMPERATURES OF BUTTERFAT
AND OF TWO FATS COMPOUNDED FOR USE IN IMITATION PRODUCTS

	50°F	70°F	80°F	92°F	100°F	110°F
Butterfat	33	14	10	3	0	0
Vegetable fat topping	55	33	19	7	5	0
Vegetable fat whitener	69	58	50	27	14	6

SOURCE: Blum (1968).

¹SFI is an empirical measure of the solid fat content. It is calculated from the specific volumes at various temperatures utilizing a dilatometric scale graduated in units of ml × 1000. Results are expressed as melting dilation in milliliters per kilogram of fat. Values in the table are the approximate percentages of solid fat at the indicated temperature (American Oil Chemists' Society 1965).

with a wide range of fatty acid composition from stabilized oils to hard coconut butters are available. Emulsifiers, vitamins, flavoring ingredients, and other desirable additives may be mixed into the fat. Some of the variations that can be built into such a fat are shown in Table 10.6 which compares the solid fat index (SFI) for butterfat and two vegetable fats. The vegetable fats were compounded to conform to the requirements of a topping and a coffee whitener.

Kinds of Simulated Products

Since ingredients and manufacturing processes for the preparation of simulated products vary so widely, no attempt will be made to reproduce formulations. Usually the processor will purchase the fat blend recommended for the product he wishes to prepare. Proprietary mixtures containing most necessary ingredients and to which only water or skim milk need be added are also available. Among the filled and/or imitation products that can be compounded are those made to resemble: chocolate milk, coffee whitener, egg nog, frozen desserts, sour cream, cream cheese, bakers' cheese, Ricotta cheese, whipped topping, and nondairy drinks of various kinds.

Coffee whitener, a kind of simulated cream which has reached large commercial production is made by drying a liquid mixture to a powder. A dry coffee whitener may contain approximately 43% each of vegetable fat and corn syrup solids, 8.5% sodium caseinate, 2% emulsifier, 1% disodium phosphate, 0.6% stabilizer, and 3% moisture.

Whipped topping has captured much of the whipping cream market. The best topping can be made with skim milk as the protein source but because the Filled Milk Act makes this illegal, sodium caseinate is widely used. Knightly (1968) in discussing the formulation of this product and the ingredients used in it gives a typical composition as: fat 30%, sodium

caseinate 2%, sucrose 7%, corn syrup solids 3–5%, stabilizer 0.3–0.5%, and emulsifier 0.35–1%.

EGG SUBSTITUTES

Attempts have been made to produce egg substitutes from milk protein but the results have not been encouraging. Preparations that contain casein and have good whipping properties have an alkaline reaction. The whey protein fraction possesses excellent foaming characteristics and can be used where the foam is not to be set by heat. But whey protein lacks the ability to form, by whipping and heat coagulation, a fine stable foam structure, a characteristic which makes egg white a unique food product.

Peter and Bell (1930) studied the whipping properties of whey protein solutions prepared from the concentrated whey liquor that is a by-product of lactose manufacture. The whipping properties of the liquor were increased when small amounts of calcium hydroxide were added to the whey liquor before it was heated to 131° F for 10 min. The alkali was neutralized and the product spray dried to yield a whipping compound for food use.

Clickner (1936) extracted the lipid material from dried whey, then added the powder to egg white as a substitute for the yolk. The whey-egg white mixture was said to equal whole egg in emulsifying properties.

Many egg substitutes were developed and used during World War II. To make one of these, a skim milk and whey mixture was neutralized with a calcium salt and concentrated. Another substitute that could be whipped to a stable foam was prepared by adding rennet extract to skim milk of 38% solids, allowing this to gel, adding sodium pyrophosphate and sodium hydroxide, digesting the mixture 4 hr, neutralizing to pH 6.5, homogenizing, and drying the product (Lindewald & Gruben 1949). A simulated egg yolk was prepared by neutralizing skim milk with sodium bicarbonate, concentrating to 40% solids, adding a slurry of bone meal, a water soluble yellow color, and disodium phosphate to bring the mix to pH 7.5, then roller drying the product (Anon. 1948). An egg white substitute which was claimed to have the whipping properties of egg white was made by condensing a mixture of 2 parts of skim milk to 1 part of whey, then neutralizing with sodium hydroxide and condensing. The concentrate of 40% solids was adjusted to pH 8.5 with lime and the mixture spray dried (Pavcek 1945).

Some modern techniques for fractionating whey are described in Chap. 11. By the use of gel filtration, electrodialysis, or reverse osmosis it is now possible to separate and concentrate whey protein without denaturing it. Such concentrates can be expected to exhibit excellent foaming properties, thus producing whips comparable to egg white but without the prop-

erty of setting to a firm structure under heat, which is unique with egg protein. A careful study of the properties of whey protein at various concentrations and pH values and at optimum temperatures might show how this protein could be prepared commercially to give it a heat-setting structural characteristic.

Skim milk has been incorporated into an egg extender prepared for the military. This is a dry material consisting of 51% whole egg, 30% nonfat milk solids, and about 15% vegetable oil (Jones *et al.* 1963). Chief use of this product is for scrambled eggs.

PRODUCTS FOR PERSONS INTOLERANT TO MILK¹

Milk products have been prepared for persons who cannot tolerate normal milk because of digestive disturbances. Intolerance to milk appears to be associated with either the lactose or protein fractions.

Lactose Intolerance

Milk sugar is common to the milk of all mammals so that it seems natural that nursing infants can metabolize this carbohydrate. Problems have arisen, however, in individuals who, at about the age of puberty, develop an intolerance to lactose which is manifested by the formation of gas, cramps, and diarrhea. Some authorities believe certain individuals have a genetic intolerance to lactose (Bayless and Rosensweig 1966). This has appeared to be the case, especially in the Negro and Oriental races. It should be noted, however, that these races do not normally drink milk after weaning and consequently may have lost their capacity to metabolize lactose. The tolerance test has sometimes consisted of feeding up to 100 gm of lactose per day, the amount present in 2.5 qt of milk. Symptoms apparently appear because of the inability of the individual to secrete lactase, the enzyme that hydrolyzes lactose. Early experiments with rats (Riggs and Beaty 1947) indicated that an appreciable tolerance could be built up by graduated feeding of increasing dosages of lactose. Starving children have sometimes shown lactose intolerance, but here it may be due to shrinkage and improper functioning of internal organs so that lactose and indeed many other foods cannot be handled properly. Where lactase deficiency does exist it is seldom absolute and the individuals can use some milk. Increasing amounts of milk could possibly be tolerated by beginning to feed very small amounts equal to a few grams of lactose per day. It might then be expected that tolerance to lactose-containing milk products would

¹The helpful counsel of E. J. Coulson in the preparation of this section is acknowledged with appreciation.

be built up after a few weeks of gradually increasing doses until a normal lactase level was reestablished. If the intolerance was due to a true allergic response to minute quantities of lactose no tolerance could be developed.

Products for Lactose Intolerance.—Products that contain no lactose are butter, cheese, and casein-containing foods. Products in which the normal lactose content is reduced or the lactose is replaced by some other carbohydrate necessitate special manufacture. Microbial fermentation of lactose discussed in Chap. 2 can produce such products as cultured butter-milk and yoghurt which may be helpful for some individuals although some lactose remains in them. One method for reducing lactose content of a standard product is hydrolysis of the sugar by lactase enzyme. This is discussed in Chap. 4 as part of a process for making frozen concentrated milk. Also discussed in the same chapter is a low lactose sweetened condensed milk for ice cream manufacture.

Protein Intolerance

Intolerance to protein may be of two types: intolerance to the type of curd formed in the stomach by casein, and true allergy.

Soft Curd Milks.—It has been known for many years that milks vary in the softness of curd which they produce in the stomach. Hill (1933) developed a test for measuring the hardness of curd produced by different milks. Whole milk, which will normally produce a hard curd measured by the Hill test, can be changed to a soft curd product by homogenization at 1500 psi or more. Thus, homogenized milk is a soft curd product. Goat's milk, because of the small diameter of its fat globules is usually soft curd. Heat treatment will produce soft curd and evaporated milk is known for its soft curd characteristics. The milk of some cows produces a softer curd than that of other cows, in part because of differences in size of fat globules and differences in casein content.

The treatment of a milk with a proteolytic enzyme will soften the curd. The enzyme treatment should not be allowed to go to the point where the milk coagulates, or where the casein is hydrolyzed to peptides which may produce bitter flavors. Enzyme treated milks have been marketed in various cities with some success. The process for their manufacture is a simple one. Milk is warmed to about 100° F, enzyme is introduced and digestion is allowed to proceed for only a short period after which the milk is pasteurized and cooled. The holding time is dependent upon temperature and enzyme concentration. Enzyme treated milk has been especially recommended for infants who cannot tolerate other forms of milk (Blatt 1939).

Milk Allergy.—Allergic sensitivity to cow's milk is primarily a problem in infants and children under 2 yr of age. It has become more prevalent as breast feeding has become less popular and the feeding of cow's milk more

common. Instances of allergy to cow's milk as observed in general pediatric practice range from 0.3% to 1.5%. Such incidences are difficult to evaluate because of the lack of generally accepted criteria for differentiating allergy from other causes of disease.

Allergy in a new born infant can arise from the fact that from birth to the second or third month of life the intestinal mucosa is permeable to undigested protein. Any food other than breast milk fed during this period conveys to the site of antibody formation a sensitizing dose of foreign protein. Antibodies form as a result of the normal immunological response of the body; then by some unknown mechanism a few infants develop varying degrees of allergic sensitivity to cow's milk. Mild to acute reactions may be observed.

Nonallergenic Products.—To produce nonallergenic products is not a simple matter, nor is there enough yet known to formulate products that will be suitable for many allergic individuals. Milk contains at least 16 antigens including globulins, albumins, and various serum proteins (Hanson and Mansson 1961). It is generally accepted that the heat denaturation of cow's milk protein that results during the manufacture of evaporated milk markedly reduces the symptoms which are usually diagnosed as milk allergy. However the beneficial effects of heated milks may be due largely to its soft curd properties rather than reduction in allergenic substances. Thus, evaporated milk is widely used in infant feeding. All the proteins are not completely denatured during the manufacture of evaporated milk, so that some infants who are extremely sensitive to any curd formation or who develop sensitivity to the protein fractions in the milk, cannot tolerate it. Milk substitute formulas then must be used, and the substituted product must not cause digestive disturbances. There are at least 30 different preparations designed for infant feeding being offered for sale in the United States. Some of these contain no milk, but are substitutes using soybean or meat based formulas. Some employ enzymatically hydrolyzed casein. Most of the products are dried but some are offered as sterile canned foods. Since it is possible to produce a very wide variety of products, formulas and manufacturing procedures will not be given. These must be developed by the manufacturer to meet the market he will enter.

ANIMAL FEED

The use of milk byproducts in animal feeds, although a large one, has been scarcely profitable. Lower grades of products have been used and the price has been approximately half that obtainable with high grade food items. Often animal feed has been manufactured to avoid an expensive waste disposal problem. Usually only the cost of production of animal feed

can be recovered, but skim milk and whey do provide the animal with important nutrients. However, considering man's future outlook for food, every effort should be made to direct these materials into human foods.

The amount of dried skim milk, buttermilk, and whey used for animals increased from 100,000 tons in 1945 to 260,000 tons in 1965. In 1945 skim milk and buttermilk were the major contributors to this figure, but it is probable that a large part of the increase in dried dairy feed production has been due to increased use of whey.

Skim Milk

When the farmer separated his own milk, cream was the cash crop and the skim milk was fed without further treatment to farm animals. Today, milk is sent to large processing plants and skim milk, sometimes surplus, is channeled into animal feed. Skim milk may be mixed with surplus whey ($\frac{2}{3}$ milk and $\frac{1}{3}$ whey) for farmers who purchase the product for calf or pig feed. Because of its high protein content skim milk makes an excellent component of animal feed. To process the product for feed it is pasteurized, condensed, and dried either by the spray or roll method.

Concentrated Sour Skim Milk

Skim milk may be preserved for feed by ripening it with a starter to develop high acidity (2%) then concentrating the product. For details of manufacture see Chap. 4. During the 1930s and early 1940s the average production of concentrated sour skim milk in the United States was about 14 million pounds per year. Since that time the feed industry has gradually shifted to dry feeds.

Buttermilk

During the first third of this century a large portion of the buttermilk produced was from sour cream. This product contained much neutralizer and was suitable for little other than animal feed. It was either fed in a liquid state or drum dried. Drying difficulties arose however because of the tendency of the acid product to form an unmanageable smear on the drying drum, a tendency for it to brown because of the high drum temperatures, and for it to become sticky and cake. These problems were partially overcome by neutralization of the sour buttermilk with lime to about 0.2% titratable acidity or less. The addition of a cereal additive improved operating conditions so that excessive temperatures and discoloration were avoided, permitting the product to be scraped from the drum.

Much buttermilk is churned now from sweet cream. This can be dried as easily as skim milk on either a drum or spray dryer. Since it has important food uses, especially in ice cream and bakery products, the amount being used for animal feed is small.

Whey

Animal feed has always been the prime use for whey that was not discarded as waste. Fluid whey is very often returned to the farm to be fed to hogs. In some areas in the United States and abroad, large hog farms were established in cheese producing areas. The whey was fed as a liquid or mixed with other feeds. A better feed can be made if much of the water is removed. An excellent hog and chicken feed can be produced by concentrating whey to between 45 and 65% solids, flowing it from the vacuum pan into lined paper cartons that hold about 25 lb. As the whey cools, the lactose crystallizes and the product sets up to a gel which can be fed directly. The whey may be fortified with vitamins or other materials if desired before it leaves the vacuum pan. It must be pasteurized before concentration. It may also be cultured with a lactobacilli to increase acid development. The high acid in the concentrate aids in preserving the product during storage.

The protein content of whey may be increased by inoculating the pasteurized cooled liquid with a culture of *Saccharomyces fragilis*. This yeast is the same culture from which lactase enzyme is prepared. For details consult Chap. 3.

Large quantities of whey are dried either on rolls or by the spray method for use as an animal feed. (See Chap. 5.) As dried whey production increases, and before sufficient food uses are developed large amounts of dry whey may be dumped as a distress product into animal feed. Minimum prices for dried acid whey are about 3.5¢ per lb for feed and 7.5¢ per lb for food.

Whey is used in specialty feeds which command a higher price than whey solids alone. Milk replacers for calves and pig starters may contain considerable quantities of dried whey. Dried skim milk and dried buttermilk may be superior for this purpose, but they are more expensive. Feed mixing companies use large quantities of dried whey in special branded feed supplements. The nutritive value of byproducts is discussed in Chap. 13.

Whey as a feed and as a fertilizer in Australia has been reviewed by Oborn (1968) as part of a general discussion of whey utilization.

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